HEAVY READING

White Paper

LTE Control Plane Optimization Strategies

Prepared by

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The Road to LTE Monetization

The purpose of this white paper is two-fold. The first objective is to consider the impact of LTE signaling protocols on service delivery monetization. The second objective is to define best practices for the creation of highly effective LTE control plane strategies.

The ramp-up of LTE deployments in 2012 is a culmination of network operator "end game" execution strategies that have been on the board since the initial rollout of 3G almost eight years ago.

And while there is industry consensus that LTE, from a pure technology perspective, is the foundation for all future mobile service innovation, implementing future mode of operation strategies is challenging from a monetization perspective.

This is in large part due to the fact that LTE provides a pure "IP" end-to-end model, which plays directly into the hands of OTT providers who can leverage the substantial download/upload speeds that LTE will deliver over 3G and the enhanced capabilities that LTE terminals possess.

Accordingly, we believe that network operators in creating holistic monetization strategies must consider both the control and data plane. While the data plane represents an obvious starting point, as we shall document in this white paper, the control plane is equally important and provides network operators new opportunities to differentiate from OTT competitors.

Therefore, in this white paper, we focus on the control plane, examining how LTE will shape the evolution of the control plane and its direct impacts on LTE monetization, which pragmatically is the metric by which next-generation mobile operators will be judged.

LTE Market Growth & Evolution Phases

In order to assess the challenges that network operators face in the optimization of LTE on the control plane, it's necessary to first understand the pace of LTE deployments, as well as the distinct evolution phases.

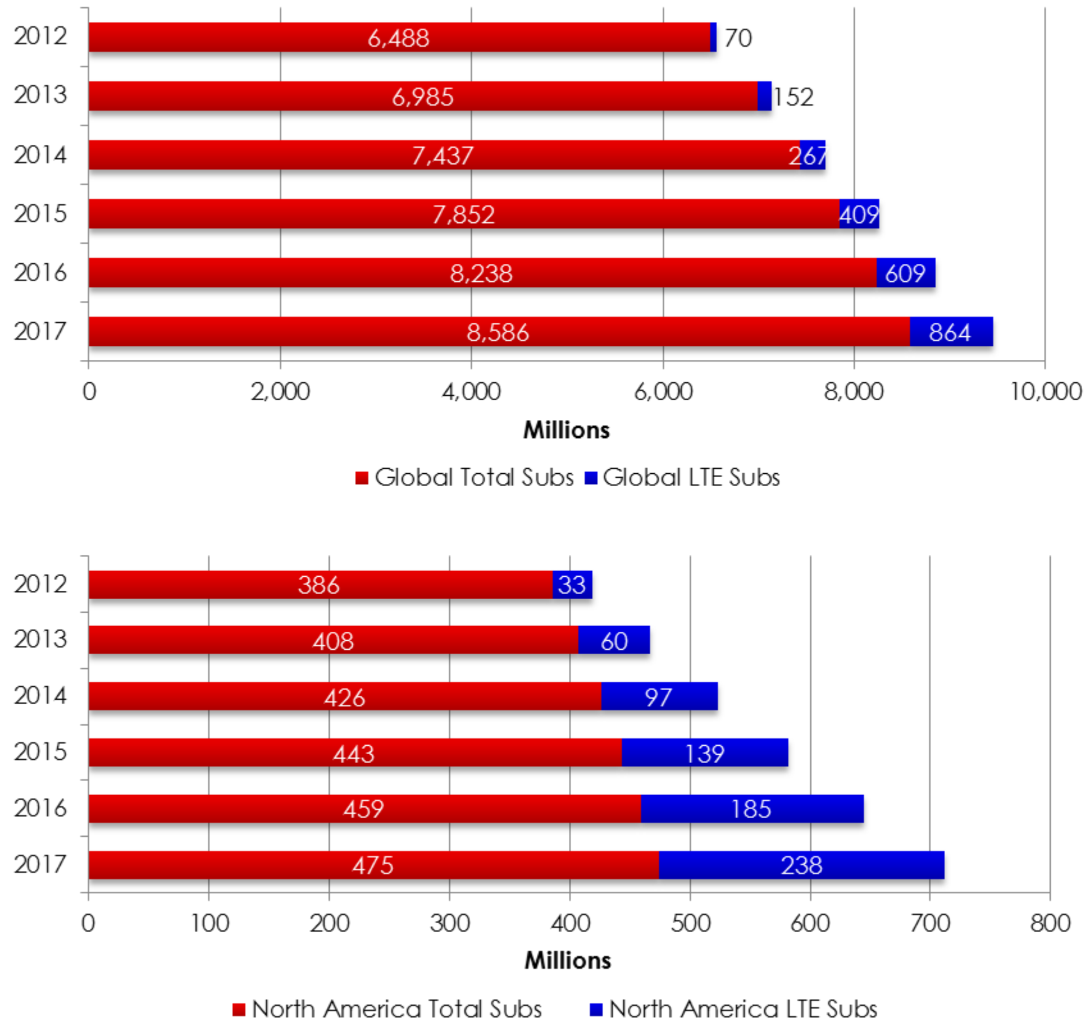
Given that we are currently experiencing first wave deployments, LTE subscriber penetration is still relatively modest, but poised for strong growth, as shown in **Figure 1** on the following page.

By the end of 2013, Pyramid Research forecasts there will be approximately 152 million LTE subscribers worldwide, with nearly 60 million of those from North America alone, as shown in the first chart below. Over the next five years, extremely strong growth will result in approximately 864 million LTE subscribers globally, of which 238 million will be from North America.

To further put this growth into context, as shown in the second chart below, approximately 50 percent of all North American subscribers will utilize LTE by 2017.

As noted above, LTE subscriber growth will be strong and gradual over the next five years. The rate of forecasted growth is due to a number of independent technical and business factors, including the time necessary to plan and gradually build out all LTE networks for complete intra-carrier coverage.

Figure 1: LTE Subscriber Growth



% LTE	2012	2013	2014	2015	2016	2017
Middle East/Africa	0.11%	0.35%	0.70%	1.22%	1.78%	2.45%
Asia/Pacific	0.85%	1.62%	2.51%	3.70%	5.83%	8.61%
Central/Eastern Europe	0.27%	0.78%	1.67%	2.89%	4.39%	6.49%
Western Europe	0.69%	2.40%	4.95%	7.69%	10.93%	14.47%
Latin America	0.42%	1.62%	3.30%	4.44%	5.72%	7.15%
North America	8.50%	14.60%	22.64%	31.41%	40.33%	50.10%
Global	**1.08%**	**2.18%**	**3.59%**	**5.21%**	**7.39%**	**10.07%**

Source: Pyramid Research

Also, network operators need to gradually shutter 2G and 3G networks to protect revenue and minimize depreciation charges. Accordingly, as shown in **Figure 2**, we define this initial phase as the **LTE Coverage Phase**. Even though this phase is vital to drive growth and market share, we consider the next phase as most important from a long-term competitive perspective.

In this second phase, which we estimate runs approximately one to three years after completion of the first phase, the focus intrinsically shifts from building out a network – to implementing a strategy for maximizing revenue from it though service innovation. Therefore, we refer to this period as the **LTE Service Phase**.

By nature, this necessitates that infrastructure focus moves from EPC and RAN and Layer 2/3 transport to core network and applications (Layer 4-7), which requires the implementation of sustainable control and data plane strategies.

Figure 2: LTE Evolution Phases

LTE EVOLUTION PATH	TIMEFRAME	CUSTOMER STRATEGY	NETWORK STRATEGY	INFRASTRUCTURE FOCUS
LTE Coverage Phase	1-5 years from first market commercial deployment	Convert 2G and 3G subs to 4G – early to market, special offers – land grab	Network build out and deployment	EPC and RAN – transport focus (Layer 2 and 3)
LTE Service Phase	1-3 years after completion of deployment and coverage phase	Monetize subscriber connectivity to grow revenue, retain customers and expand service model	Innovate – find a way to make it all work end-to-end and to generate new revenue streams	Applications and core (Layer 4-7)

LTE Network Control Plane Protocol Primer

As already described, the LTE network control plane performs an indispensable role in service delivery and application support. Although network operators may tend to consider application delivery in a Layer 7 context, Layer 5 or session layer is also important, since foundationally it enables the set-up and tear-down of sessions necessary to invoke these applications.

Therefore, in order to develop an all-inclusive strategy, operators must consider two distinct protocol pillars in a single context: Session Initiation Protocol (SIP) and Diameter.

SIP

As the name suggests, SIP is a protocol specifically designed to support Layer 5 session requirements for applications that run on IP networks. To ensure IP inter-working SIP utilizes a text-based request and response structure similar to HTTP.

Consequently, SIP is extremely flexible and can perform a number of key functions, including modifying session requirements to allow the transfer of specific media/ application streams on both a one-to-one or one-to-many end-user basis. *Perhaps* *the best way to describe the role of SIP is as the default protocol that enables an IMS-based network to establish the "state machine" necessary to enable routing, billing, and authentication requests from subscribers.*

While SIP has been in the mass-deployment phase for more than seven years, initially in fixed IP networks and then 3G mobile networks, with the deployment of Release 4, which introduced IP into the core, the pace of deployments in mobile networks will accelerate, given that SIP is the only standardized approach for session control between core network elements such as Interrogating and Serving Call Session Control Functions (I/S-CSCF), application servers and network elements found at the service edge, such as session border controllers (SBCs).

Moreover, since VoLTE is IMS-based, by default SIP will have to be supported in 4G mobile networks for interworking of services for roaming subscribers.

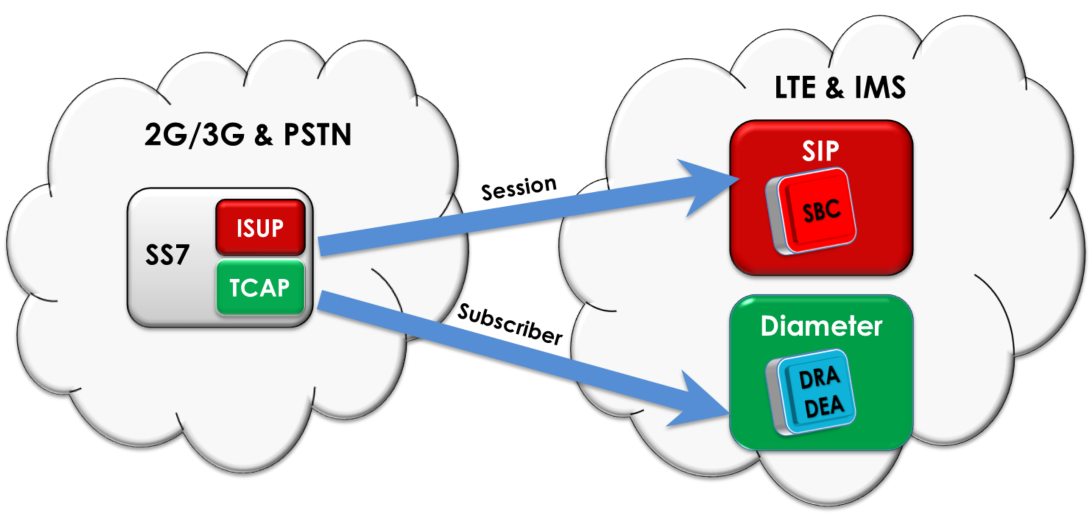
SIP supports two unique variations – SIP-I (ISUP) defined by the ITU and SIP-T (Telephony) defined by the IETF, which are very similar in that both support the encapsulation of ISUP messaging over IP to enable session interworking at the session layer with legacy networks to support traditional services such as fax.

As shown in **Figure 3**, this means that SIP can be used to replace the functions of legacy SS7 ISUP, while also supporting the additional requirements inherent within IP services. Ultimately, via deployment of SBCs that interwork between native SIP, SIP-I and SIP-T, complex, network-specific routing and access models for applications never contemplated in the design of SS7 nearly three decades ago can be supported.

Diameter

As shown in **Figure 3**, the Diameter protocol, like SIP, is designed to functionally replace a defined capability of SS7: TCAP.

Figure 3: LTE vs. 2G/3G Control Protocol Evolution



Source: Oracle/Heavy Reading

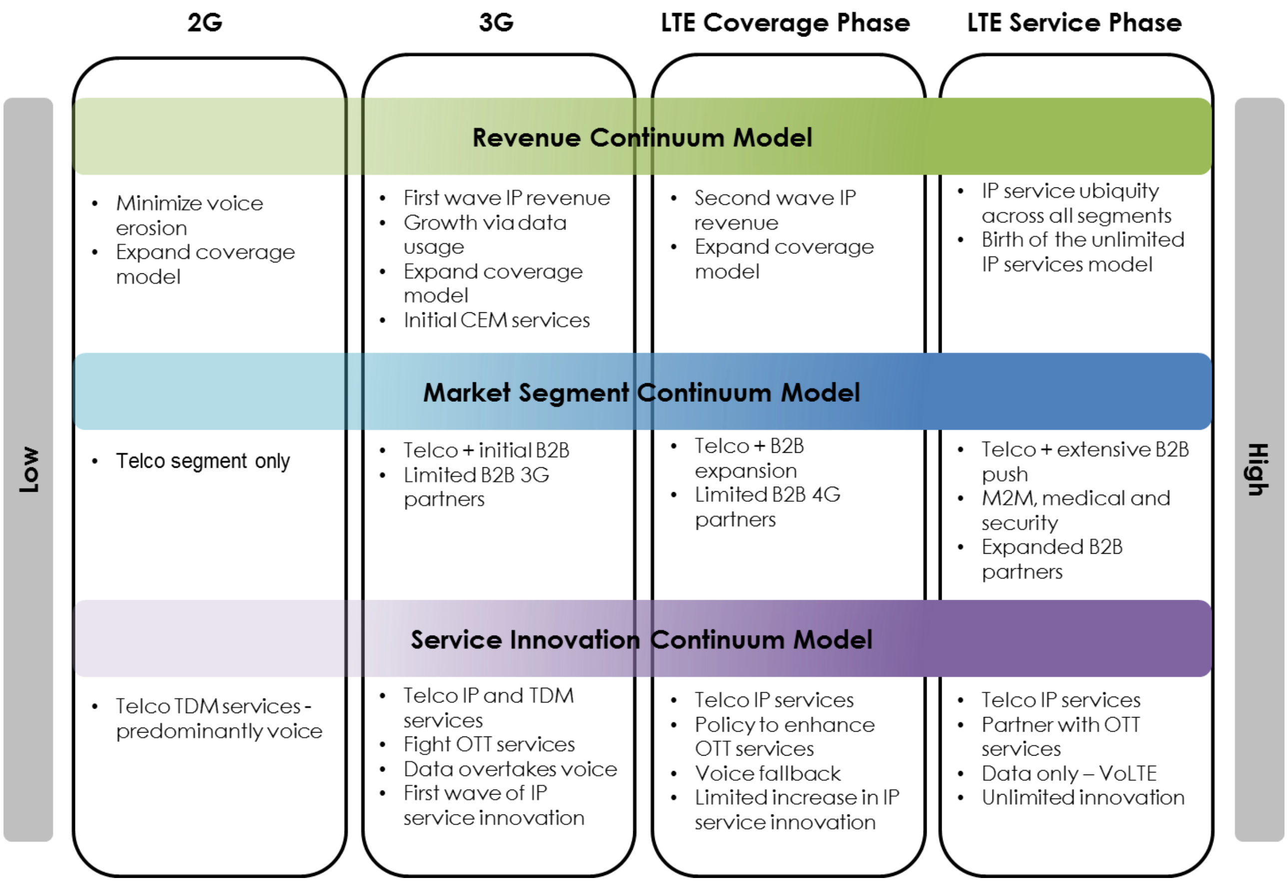
Similar to SIP, Diameter provides a flexible template for supporting new control plane functions such as QoS and resource allocation, which were not contemplated in TCAP design. To meet these additional requirements, two standalone Diameter nodes have been standardized – a Diameter Routing Agent (DRA) for intra-network traffic and a Diameter Edge Agent (DEA) for inter-network traffic.

LTE Service Model Evolution & Control Plane Impact

Although LTE is now a commercial reality, aligned with the various phases of LTE described above, we consider the LTE service model as still in development mode.

Therefore, perhaps the best way to characterize LTE services advancement, as shown in **Figure 4**, is a highly dynamic continuum, which will ultimately leverage the superior and IP-based connectivity model in new market segments not previously accessible to mobile operators.

Figure 4: The Mobile Network Services Continuum



Source: Heavy Reading

LTE Control Plane Monetization Use Cases

In this section we present two use cases to illustrate the vital role that SIP and Diameter play in the process of LTE services monetization. These use cases are VoLTE; and H2M and M2M LTE medical imaging.

Although these use cases are unique in terms of customer segment, content and end-user expectations, to be successfully monetized they must both excel at meeting the following basic network requirements/capabilities:

- Authentication
- Billing
- Policy control
- QoS and overload control
- Security

LTE Use Case 1: VoLTE

One of the dilemmas that operators face in the adoption of an all-IP LTE model is how to most effectively handle voice traffic. While interim approaches such as TDM-based circuit-switched fallback (CSFB) will be required as a go-to-market strategy, as global coverage reaches critical mass during the **LTE Service Phase**, the move to packetized voice via VoLTE will become necessary.

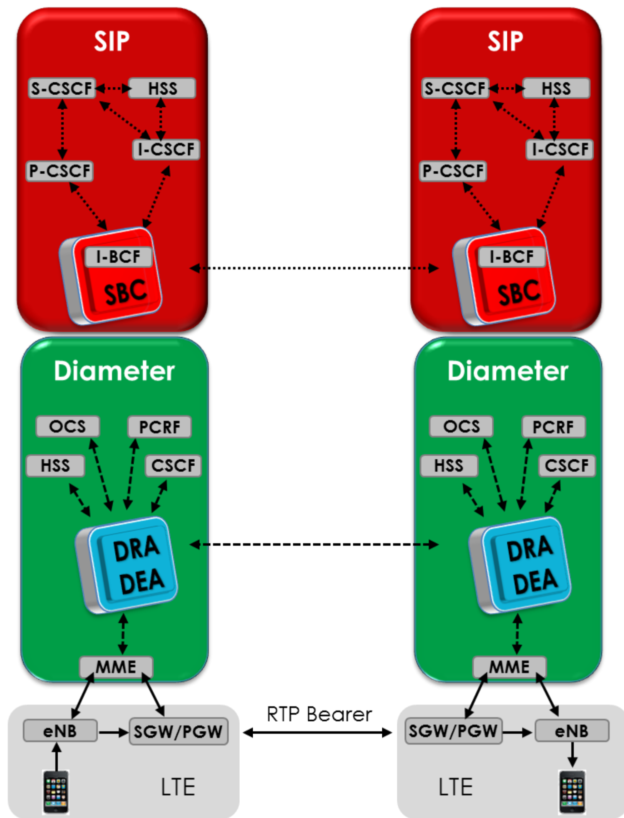
While voice quality will not initially improve with interim TDM fallback approaches, in the longer term, when VoLTE is supported between two networks, it will enable the support of HD voice codecs on both "ends of the call," which will provide a much improved subscriber experience.

Figure 5: The Importance of SIP & Diameter: VoLTE Use Case

FUNCTION	IMPORTANCE OF SIP SIGNALING	IMPORTANCE OF DIAMETER SIGNALING
Authentication	**High:** SIP supports VoLTE subscriber authentication in the HSS.	**High:** Diameter used to access AAA servers and to support VoLTE handover via the MME.
Billing	**Medium:** To support billing a correlation ID for each SIP event is transmitted between nodes via SIP.	**High:** VoLTE billing charging information is transferred from IMS nodes to OCS via Diameter interfaces.
Policy Control	**Medium:** SIP provides session connectivity between policy nodes to enforce specific access policies.	**High:** DRA plays an important role in VoLTE QoS policy enforcement by managing load-balancing between PCRFs.
QoS and Overload Controls	**High:** VoLTE leverages the extensibility of SIP to support routing based on a specific QoS Class Identifier (QCI) to enable QoS.	**High:** DRA/DEA minimizes point-to-point connections between nodes, thereby reducing latency. Also supports message routing utilizing a specific priority code.
Security	**High:** SIP supports IPsec-based encryption tunnels between IMS nodes to ensure sessions cannot be "hijacked."	**High:** DRA/DEA node acts as a single secure point of network entry.

This end-to-end approach will also be an invaluable defense against further erosion of voice revenues from OTT competitors. In addition, since VoLTE (unlike OTT apps) supports emergency services, there is potential to achieve competitive differentiation simply through basic regulatory compliance. Perhaps more importantly, VoLTE support means that mobile operators no longer face a significant hurdle to shutting down TDM 2G networks. To make this vision a reality, as illustrated in **Figures 5** and **6**, SIP and Diameter DRA/DEA nodes play a central role.

Figure 6: VoLTE Architecture



Source: Heavy Reading

LTE Use Case 2: H2M & M2M Medical Imaging

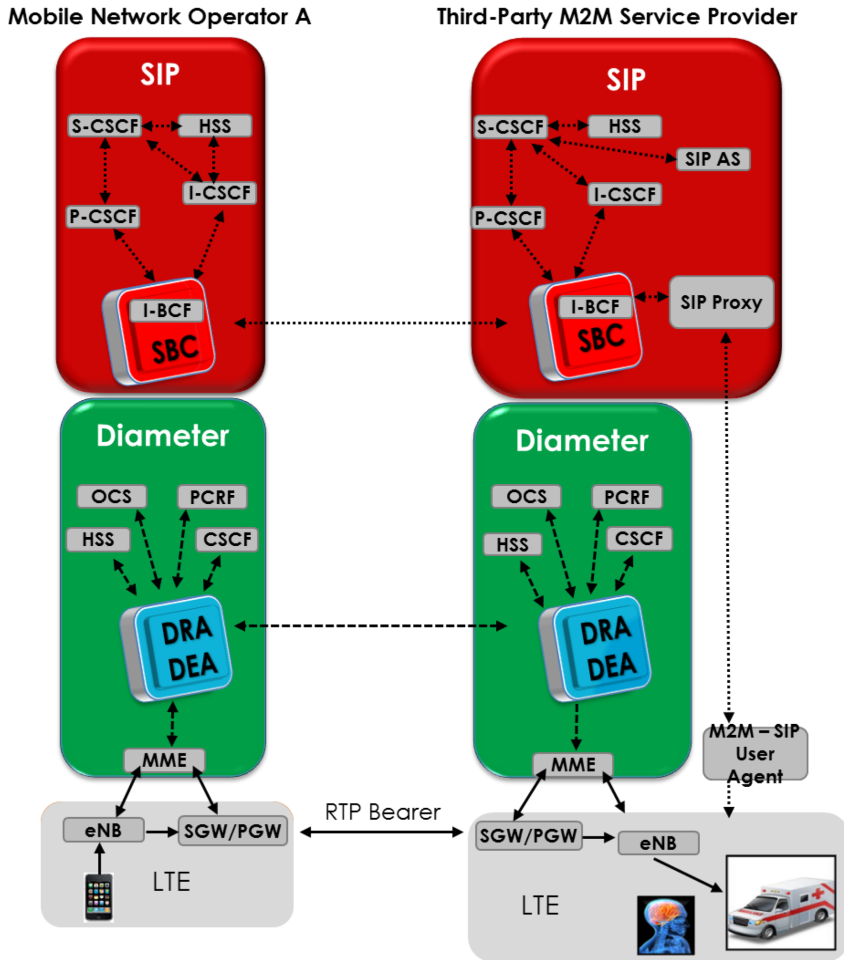
While the concept of accessing machine-to-machine (M2M) devices via a mobile network is well relatively well understood, pinpointing which applications will be accessed is much more challenging.

Essentially, the approaches can be divided into two camps. The first believes the market driver is the ability to monitor home devices via an embedded SIM, potentially using an SMS push system. For these types of basic services with limited or no mobility, 2G networks are viewed as the natural approach. The second camp advocates that the future of telcos is based on support for high-value IP mobile broadband services. This philosophy makes more sense for several reasons.

First, as we noted earlier, it opens the door to more fruitful alliances between B2B partners which in the long term leads to substantial revenue growth. In addition, this market is still extremely supple and unlimited from a services innovation perspective including, extending, for example, to exploit a human-to-machine (H2M) model. The 2G M2M model, on the other hand, is extremely limited both from a technology and a business perspective.

In addition, if you consider that the end game for mobile operators is to collapse legacy networks and cultivate new revenue streams to cover 4G network deployment costs, then aggressively targeting these high-value LTE services must be a strategic imperative. Simply packetizing voice and allowing subscribers to access OTT applications does not represent a formula for success. We therefore believe, as illustrated in **Figure 7**, that LTE is best positioned to support high-value services such as medical imaging that also leverage mobility to a much greater extent to support transfer of this data regardless of location at true broadband speed – something that was not available even a few years ago.

Figure 7: H2M/M2M LTE Based Medical Imaging



Source: Heavy Reading

Figure 7 depicts a scenario in which a medical staff is able to gain access and download a medical scan from an ambulance utilizing a third-party-developed SIP-based solution that is hosted in the application server of another LTE mobile provider. Similar applications running on LTE networks have been demonstrated at events such as the Consumer Electronics Show (CES).

The significance of this approach vs. the 2G model is that, as shown in **Figure 8**, it also relies heavily on both SIP and Diameter for enabling service advancement and monetization.

Figure 8: The Importance of SIP & Diameter: LTE Medical Imaging Use Case

FUNCTION	IMPORTANCE OF SIP SIGNALING	IMPORTANCE OF DIAMETER SIGNALING
Authentication	**High:** SIP is required to set up sessions between human device and LTE medical image device.	**High:** Diameter utilized to support authentication of medical imaging device.
Billing	**Medium-Low:** SIP session are required to setup the data exchange but likely not processed by the mobile operator.	**Medium-Low:** A DRA/DEA may be required to support transfer of billing data to a telco OCS node.
Policy Control	**High:** SIP will be tasked with setting up sessions between clients and potentially a Media Resource Function (MRF) server.	**High:** M2M and H2M applications require complex policy enforcement rules.
QoS and Overload Controls	**High:** SIP will be provisioned so that high value application sessions such as medical imaging are provided the highest priority, regardless of network performance.	**High:** A DRA/DEA can minimize the signaling effects of a medical application-induced signaling storm.
Security	**High:** In this scenario, SIP plays a critical function, including session creation with application-specific gateways for password validation.	**High:** DRA/DEA ensures that data stored on applications are "hidden" and not visible to a third party.

LTE Control Plane Implementation Challenges

In this section we explore some of the implementation challenges that network operators must consider when implementing SIP and Diameter as part of an extensive LTE control plane strategy.

Protocol Pitfalls

Modern protocols such as SIP and Diameter are by design highly extensible to ensure that they can be implemented in a number of yet-to-be-determined use cases. Characteristically, this means that basic functions are supported in the least complicated manner, with the potential to support additional functions added based on specific requirements.

This is why SIP is often referred to as a "lightweight protocol." Similarly, Diameter incorporates attribute-value pairs, which enables the protocol to flexibly encapsulate information based on application requirements. Although this approach is unquestionably necessary to ensure both can meet future service demands, there are a number of inherent challenges that confront vendors and carriers alike.

Standards Definition: Normative "Must" vs. an Informative "Shall" vs. a Backward Compatible "May"

In the case of SIP, there are two parallel implementations from ITU and IETF (SIP-I and SIP-T), which perform very similar capabilities, but possess different execution methodologies. By nature, this means that operators must ensure their vendors have roadmaps that can support multiple implementations for global interworking.

This, however, is not a new issue. SS7, for example, supports a number of additional specifications, including the ITU, ETSI and the former Telcordia and country-specific implementations of ISUP (e.g., Japan and China), which mandates a multi-variant implementation approach.

Diameter also has some unique standards-associated issues. The first of these is that not all subsequent releases of Diameter are backwards compatible with previous releases. Similar to the IPv4 and IPv6 impasse, this means a dual implementation approach is often necessary.

Additionally, both are subject to the impacts of the standards processes. By this we mean that, since standards-based specifications are negotiated by a number of interested parties, implementation details may not be rigidly defined. This results in the definition of optional vs. mandatory parameters in protocol headers, which complicates vendor interoperability if only one vendor has implemented these optional parameters.

Similarly, since standards specifications are intended to provide a template that telecom vendor software developers can utilize to create their solutions, a number of procedures are defined. In order to differentiate functions that are mandatory vs. optional, specifications such as Diameter and SIP utilize terms such as *SHALL* or *MUST* to capture the former and terms such as *MAY* or *SHOULD* to capture the latter. Note the following:

> *A Diameter node MAY act as an agent for certain requests while acting as a server for others (source: RFC 6733).*

The disadvantage of this approach is that it leaves ambiguity for implementers and ultimately limits the potential for "plug and play" interoperability. What's more, this ambiguity within "standards" is neither occasional nor rare; RFC 6733 utilizes the MAY convention approximately 100 times.

And finally, standards specifications often utilize both *normative* and *informative* text. While normative text specifically is considered to represent the policies and procedures defined to assess overall standards compliance (subject to usage of MAY vs. SHALL), informative text is designed to provide background on the concepts utilized by the standard or to introduce new concepts that may be moved into the normative section in future releases. As a result, if a vendor implements some capability in the informative section, there is no requirement for other vendors to support or perform interoperability testing.

The Indelible Perpetuity of the IP Threat Curve

Another challenge of utilizing extensible protocols such as SIP and Diameter is the ability of hackers to exploit the inherent vulnerabilities of end-to-end IP networks. While both SIP and Diameter support IPsec and can leverage policy control and standalone architectures to support topology hiding, since 4G services are fully IP end-to-end, there are no shortages of potential vulnerabilities.

And given that future service innovation and customer experience will be solely IP-based, it will forever be subject to this concern. While the industry is taking concerted steps to address these vulnerabilities, there is little doubt that the threat curve will become a greater issue as IP migrates into non-telecom segments such as smart grids via telco-utility B2B agreements.

LTE Control Plane Strategy Best Practices

In this section we define best practices that network operators must adopt for creation of an effective LTE control plane strategy.

Best Practice 1 – Decouple Protocols From Hardware

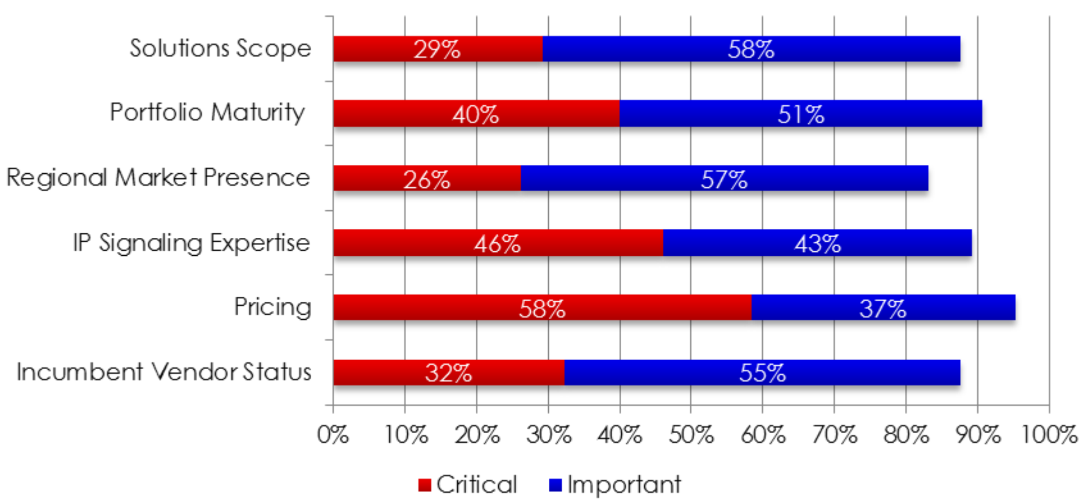
Given the standards ambiguity and consequent variances in software implementation, there is enough to be concerned about in terms of SIP and Diameter interoperability between vendors. Therefore, it's critical that there not be a hardware dependency as well. Stated another way: *The practices of specific releases and unique/specialized protocol implementations are no longer sustainable.* Decoupling protocols from hardware also represents the lowest implementation software model, which is critical for monetization and profitability.

Best Practice 2 – Define an IP Protocol Services Strategy for LTE

Since IP service driven is now open-ended and unrestricted by legacy telecom protocols, network operators must ensure they have both comprehensive short-term and long-term LTE services roadmaps. For example, an operator LTE service strategy must address not only "telecom" services but also, as previously discussed, new B2B market segments such as mobile health services, m-commerce and home security services, given that is where LTE will flourish as well.

Key considerations include confirming vendors have a roadmap that maps to your strategy and features a progressive approach. Specifically, in considering vendor IP roadmaps, it's important to consider how vendors themselves are transitioning to an IP focus vs. relying on legacy services to control the pace of IP migration and monetization. This message is starting to get through to operators. As a proof point, in a recent *Heavy Reading* Diameter signaling study, operators provided insight into Diameter selection criteria.

Figure 9: Diameter Vendor Selection Criteria



Source: Heavy Reading Diameter Signaling Multi-Client Study, November 2012

As highlighted in **Figure 9**, the survey showed the criticality for a vendor to have strong expertise in IP – second only to pricing and more important than traditional factors such as vendor incumbency.

Best Practice 3 – Adopt a Unified Protocol Strategy

As we have documented, SIP and Diameter perform crucial but different roles in LTE control plane optimization. However, it's still important when developing a control plane strategy that operators consider and adopt a holistic protocol strategy. This requires that a single framework be put in place to ensure that base protocol strategies for both SIP and Diameter are aligned with, and conform to, the LTE services definition process. Specifically, in terms of selecting vendors, we believe that vendors whose portfolios include both SIP and Diameter-based solutions are best positioned to help operators implement a common vision.

Best Practice 4 – Virtually Prepare for Final Convergence

Since the fall of 2012 when the concept of network functions virtualization (NFV) emerged, it has become clear that the line between IT and core network domains are not only continuing to blur, they are being totally erased as telco network functions formally converge by moving into the IT domain.

Consequently, as network operators define their IP services vision, they must adopt an open-minded stance that future services may run in virtually any location – cloud, core, or edge. This strategy will also impact which technology partners they select. Ultimately, we believe that vendors that possess credible experience and products in all these domains are best positioned for long-term success.

Conclusion

Even though SIP is more than a decade and a half old, it is only now really poised to achieve the dominant footprint that was originally conceived during the creation of the initial specifications. This is due to the increased penetration of SIP into mobile networks to not only support basic session creation, but more importantly – as we have documented in this white paper – to support the **LTE Service Phase**.

Likewise, Diameter, which was standardized approximately 15 years ago, is only now positioned for strong growth in mobile networks, as IP becomes the dominant fabric in the RAN and the service core. And also like SIP, Diameter is now considered a services enabler vs. simply network "plumbing" infrastructure providing the header and protocol structure for allowing network functions to execute basic routing and billing functions.

Therefore, while LTE mobile operators will continue to face challenges to succeed in the **LTE Service Phase**, we believe that these two protocol stalwarts, when considered in union, provide a stable and flexible template for future human and machine mobile service innovation.

Appendix A: About the Author

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Jim Hodges has worked in telecommunications for more than 20 years, with experience in both marketing and technology roles. His primary areas of research coverage at *Heavy Reading* include softswitch, IP Multimedia Subsystem (IMS) and application server architectures and virtualization, control plane protocols such as Diameter and OpenFlow, IP service delivery, subscriber data management (SDM) and managed services.

Hodges joined *Heavy Reading* after nine years at Nortel Networks, where he tracked the VoIP and application server market landscape, most recently as a senior marketing manager. Other activities at Nortel included definition of media gateway network architectures and development of Wireless Intelligent Network (WIN) standards. Additional industry experience was gained with Bell Canada, where Hodges performed IN and SS7 planning, numbering administration and definition of regulatory-based interconnection models.

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